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PETROLOGY OF THE GARNET AMPHIBOLITES FROM THE TEJIĆI VILLAGE (POVLEN MT., WESTERN SERBIA)

by

Danica Srećković–Batoćanin*, Dragan Milovanović*
and Kadosa Balogh**

Different metamorphic rocks discovered near the village of Tejići (Povlen Mt., Western Serbia) represent members of the olistostrome mélange metamorphosed during the obduction/emplacement of some still hot ultramafic body. They occupy the area of about 2 km^2.

The garnet amphibolites are of highest metamorphic grade in the area of Tejići and were chosen as the most convenient rocks for determination the pressure–temperature conditions of metamorphism and of ultramafics during their emplacement.

Key words: amphibolites, ophiolite complex, olistotrome mélange, metamorphism, emplacement.

Метаморфне стене, откривене на површини од око 2 km^2 у селу Тејићи (Повлен, западна Србија) су делови олистостромског меланжа промењени при смештају/обдукцији ултрамафита, односно делови метаморфне подлоге офиолитског комплекса.

На највишим притисцима и температурама, на самом контакту са ултрамафитима су образовани амфиболити са гранатима, па тим представљају најпогодније стене за одређивање услова метаморфизма, односно степена загрејаности ултрамафита у време смештаја/обдукције.

Кључне речи: амфиболити, офиолитски комплекс, олистостромски меланж, метаморфизам, смештај.

INTRODUCTION – GEOLOGICAL SETTING

The village of Tejići is located in the so–called "Mesozoic zone", situated between two large areas: the Drina–Ivanjica and the Jadar Paleozoic. This zone was separated by Petković (1930–1931). According to Mojsilović et al., (1966, 1975), different sedimentary, igneous and metamorphic rocks within this zone, excluding only some large blocks, were regarded as members of the "Diabase–Chert Formation", until Dimitrijević & Dimitrijević (1974) explained this formation as the ophiolitic mélange.

* University of Belgrade, Faculty of Mining and Geology, Djušina 7, 11 000 Belgrade (e-mail: milovdr@beotel.yu).

** Institute for Nuclear Research – "ATOMKI", Debrecen, Hungary (e-mail: balogh@moon.atomki.hu).

This area is a part of the western subzone of Vardar Zone Composite Terrane (Karamata & Krstić, 1996; Fig. 1). The Vardar Zone Composite Terrane is in the area of Tejići only about 5 km in width and thrusted over the Drina–Ivanjica Terrane on west, and over Jadar Block/Terrane, on east. It is composed of dismembered ophiolite complex, Triassic, mainly carbonaceous, and Liassic and Cretaceous carbonaceous blocks, and of sandstone blocks as the less abundant, all in clayey-silty matrix.

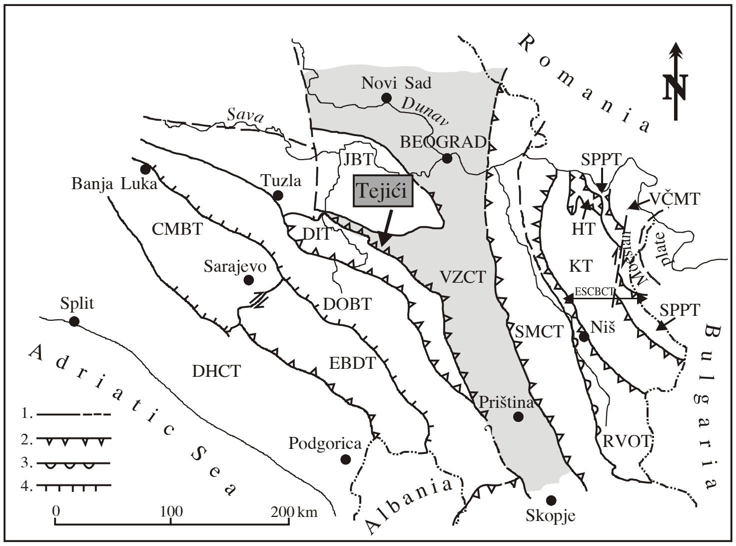

Fig. 1. The terranes in the central part of the Balkan peninsula, between Moesian plate and the Adriatic sea (Karamata & Krstić, 1996). From east to west: Moesian plate; ESCBT– The Composite Terrane of Carpatho–Balkanides; VČMT– The Vrška Čuka–Miroč Terrane; SPPT– The Stara Planina–Poreč Terrane; KT– The Kučaj Terrane; HT– The Homolje Terrane; RVOT– The Ranovac–Vlasina–Osogovo Terrane; SMCT– The Serbian–Macedonian Composite Terrane; VZCT– The Vardar Zone Composite Terrane; JBT– The Jadar Block Terrane; DIT– The Drina–Ivanjica Terrane; DOPT– The Dinaric Ophiolite Belt Terrane; EBDT– The East Bosnian–Durmitor Terrane; CBMT– The Central Bosnian Mts. Terrane; DHCT– The Dalmatian–Herzegovian Composite Terrane; 1. fault, observed and covered; 2. overthrust, observed and covered; 3. unclear relation; 4. tectonized boundary.

Сл.1. Терани централног дела Балканског полуострва, између Мезијске плоче и Јадранског мора (Karamata & Krstić, 1996). Са истока на запад: Мезијска плоча; ESCBT– Композитни теран Карпато–балканида; VČMT– Вршка Чука–Мироч теран; SPPT– Стара планина–Пореч теран; KT– Кучај теран; HT– Хомоље теран; RVOT– Рановац–Власина–Осогово теран; SMCT– Композитни теран Српско–македонске масе; VZCT–Композитни теран Вардарске зоне; JBT– Теран Јадарског блока; DIT– Дринско–ивањички теран; DOPT– Теран офиолитског појаса Динарида; EBDT– Теран Источне Босне и Дурмитора; CBMT– Теран Централних Босанских планина; DHCT– Композитни теран Далмације и Херцеговине; 1. расед, запажен и покривен; 2. краљушт, запажена и покривена; 3. нејасни односи; 4. тектонска граница.

In the area of Tejići the ophiolite complex comprises ultramafic rocks (tectonites), gabbros, diabases (the lowest part of the "sheeted dyke" complex) and metamorphic rocks, that form an discontinuous belt with average thickness of 200 m, locally up to 1000 m. Ultramafic cumulates are rare or completely absent, while the pillow lavas occur separately, further to the north.

Metamorphic rocks include amphibolites, various schists and seldom gneisses. Garnet amphibolites were discovered as a few meters thick bodies next to ultramafic rocks, while further from the contact amphibolites without garnet occur.

Garnet amphibolites were chosen for detail investigation, as they represent the rocks of the highest metamorphic grade in this area, i.e. the most convenient rocks for determination the pressure–temperature conditions of metamorphism and of the ultramafics during their emplacement.

ANALYTICAL METHODS

Samples were chemically analyzed for major and trace elements by X–ray fluorescence, while REE analysis was done by ICP techniques at the Mineralogical Institute in Köln (Germany). FeO in rocks was determined by titration with a standardized potassium permanganate solution at the Aristotle University (Thessaloniki, Greece).

Microprobe analyses are performed by G. Christofides at the Aristotle University (Thessaloniki, Greece), while K/Ar analyses were done by K. Balogh at the Institute for Nuclear Research in Debrecen (Hungary).

Table 1. Representative microprobe analyses of amphiboles.
Табела 1. Хемијски састав и структурне формуле амфибола.

	1–•	1–o	2–•	2–o	3–•	3–o	4–•	4–o
SiO_2	44.08	43.01	43.32	43.51	44.25	43.89	44.83	45.68
TiO_2	0.97	1.16	1.04	1.11	1.13	1.08	1.14	0.70
Al_2O_3	14.74	14.13	14.03	14.78	15.03	13.85	15.23	13.03
FeO	13.56	14.92	14.84	13.39	13.62	14.61	13.80	15.29
MnO	0.41	0.34	0.47	0.32	0.33	0.49	0.33	0.38
MgO	11.54	10.20	10.53	11.25	11.44	10.34	11.59	10.31
CaO	10.86	11.66	12.22	10.82	11.00	11.78	11.15	12.59
Na_2O	1.34	0.96	1.05	1.40	1.42	0.95	1.44	0.86
K_2O	0.69	0.60	0.59	0.67	0.68	0.64	0.69	0.42
Σ	98.19	96.98	98.09	97.25	98.90	97.63	100.20	99.26
Number of ions on the basis of 23(O) – Број јона на бази 23(O), 13–CNK								
Si	6.293	6.318	6.318	6.285	6.285	6.407	6.285	6.596
^{IV}Al	1.707	1.682	1.682	1.715	1.715	1.593	1.715	1.404
^{VI}Al	0.771	0.763	0.728	0.800	0.799	0.787	0.800	0.812
Fe^{3+}	0.908	0.606	0.499	0.809	0.812	0.496	0.809	0.226
Ti	0.104	0.128	0.114	0.121	0.121	0.119	0.120	0.076
Mg	2.456	2.234	2.290	2.423	2.422	2.250	2.422	2.219
Fe^{2+}	0.711	1.227	1.311	0.809	0.806	1.287	0.809	1.620
Mn	0.050	0.042	0.058	0.039	0.040	0.061	0.039	0.046
Ca^A	1.661	1.835	1.910	1.675	1.674	1.842	1.675	1.948
Na^A	0.339	0.165	0.090	0.325	0.326	0.158	0.325	0.052
Na^B	0.032	0.109	0.207	0.067	0.065	0.111	0.066	0.189
K^B	0.126	0.112	0.110	0.123	0.123	0.119	0.123	0.077

• – core of grain (центар зрна); o – rim of grain (ободни део зрна).

PETROGRAPHY AND CHEMISTRY OF MINERALS

Garnet amphibolites are massive, sometimes banded rocks of nematoblastic texture. They are exposed on the southeastern slopes of Kosa next to ultramafic rocks. Their outcrops are about few m^2 and in sharp, i.e. tectonic contact with ultramafic rocks. They consist of amphibole, plagioclase, garnet and epidote, chlorite and prehnite are secondary minerals, while the very seldom rutile is the only accessory constituent.

Amphibole occurs as needles up to 3 mm in diameter, which are gathered in laminaes defining S_1 foliation. Rare occurrences of poorly orientated amphiboles indicate the minor mineral growth after the peak of deformation. Amphibole grains make between 30% and 50% vol. of these rocks. They are nearly homogenous in composition and without regular differences between their core and rim (Table 1). According to Leakes classification (1978) amphiboles correspond to hornblende (Fig. 2).

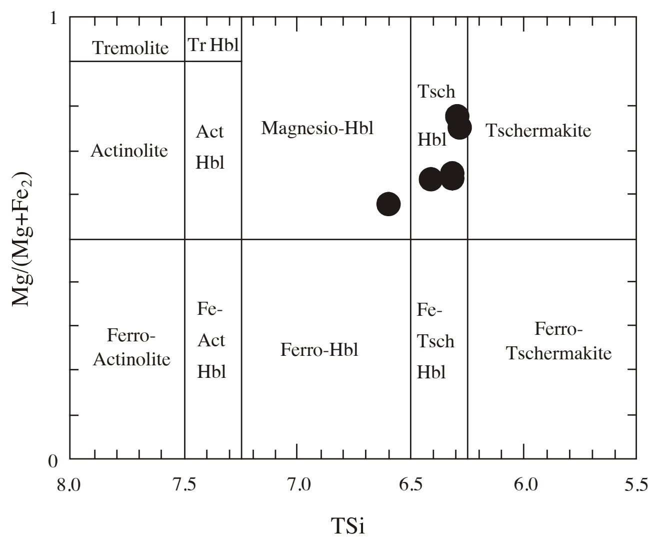

Fig. 2. Composition of amphiboles from garnet amphibolites according to IMA nomenclature (Leake, 1978).
Сл. 2. Хемијски састав амфибола из амфиболита са гранатима (Leake, 1978; Tremolite=тремолит, Actinolite=актинолит, Tschermakite=чермакит, Tr=tremolitska, Hbl=хорнбленда, Act=актинолитска, Fe, Ferro=гвожђе, Tsch=чермакитска, Magnesio=магнезијска).

Amphibole grains often enclose garnet and rutile grains. Sometimes they are chloritized on their rims, rarely in their central parts. This chlorite corresponds to corundophillite or to ripidolite (Table 2).

Plagioclase is the second main constituent and build from 30 to 40% vol. of these rocks. Primary plagioclase grains are almost completely transformed to epidote – prehnite aggregates. Their size is about 0.8×1 mm, while the newly formed plagioclases are in irregular grains up to 0.5×0.8 mm in size. According to results of microprobe analyses this newly formed plagioclase is almost pure albite with up to 2% of anorthite component (Table 3).

Table 2. Selected microprobe analyses of chlorite.
Табела 2. Хемијски састав хлорита.

%	1	2	3	4	5	6
SiO_2	27.92	28.02	28.69	27.90	27.82	28.16
TiO_2	0.01	0.04	/	0.07	0.02	/
Cr_2O_3	0.32	/	0.04	0.16	/	0.16
Al_2O_3	19.04	19.18	19.16	19.26	18.67	19.01
FeO*	22.71	22.70	23.68	22.99	23.10	23.44
MnO	0.41	0.74	0.40	0.50	0.70	0.66
MgO	17.51	16.99	17.11	17.19	16.73	17.11
NiO	/	0.11	0.01	0.19	0.26	/
CaO	0.06	0.01	0.19	0.06	0.05	0.03
Σ	87.98	87.79	89.30	88.35	87.37	88.57
Number of ions on the basis of 28(O) – Број јона на bazi 28(O)						
Si	4.9490	4.9798	5.0198	4.9362	4.9902	4.9763
Ti	0.0013	0.0053	0.0000	0.0093	0.0027	0.0000
Cr	0.0448	0.0000	0.0055	0.0224	0.0000	0.0224
Al	3.9776	4.0174	3.9510	4.0160	3.9469	3.9592
Fe^{2+}	3.3665	3.3739	3.4649	3.4016	3.4652	3.4640
Mn	0.0616	0.1114	0.0593	0.0749	0.1064	0.0988
Mg	4.6262	4.5006	4.4621	4.5331	4.4729	4.5066
Ni	0.0000	0.0157	0.0014	0.0270	0.0375	0.0000
Ca	0.0114	0.0019	0.0356	0.0114	0.0096	0.0057
K	0.0000	0.0000	0.0045	0.0068	0.0046	0.0000

– total Fe is expressed as FeO (укупно Fe дато као FeO*).

Table 3. Selected microprobe analyses of plagioclase.
Табела 3. Хемијски састав плагиокласа.

%	1	2	3	4	5	6
SiO_2	68.91	68.54	69.08	70.89	70.73	60.48
Al_2O3	18.97	18.60	18.74	18.89	18.97	19.44
CaO	0.04	0.02	/	/	/	/
Na_2O	12.07	11.95	12.15	9.50	9.67	11.65
Σ	99.99	99.11	99.97	99.28	99.37	100.57
Number of ions on the basis of 32(O) – Број јона на бази 32(O)						
Si	3.0036	3.0153	3.0107	3.1769	3.1622	3.0214
Al	0.9745	0.9644	0.9626	0.9977	0.9996	0.9963
Ca	0.0019	0.0009	0.0000	0.0000	0.0000	0.0000
Na	1.0200	1.0193	1.0267	0.8254	0.8382	0.9823
%An	0.20	0.10	0.00	0.00	0.00	0.00
%Ab	99.80	99.90	100.00	100.00	100.00	100.00

Garnet grains are euhedral, up to 0.8 mm in size. According to their chemistry they are almandine with 18-23% of pyrope, up to 13% of grossulare and up to 11% of spessartine component (Table 4). A difference between their core and rim is notably, especially for the MgO content which is regularly higher in the central parts of garnet grains.

Table 4. Representative microprobe analyses of garnets.
Табела 4. Хемијски састав граната.

%	1–o	1–•	2–o	2–•	3–o	3–•	4–o	4–•	5–o	5–•
SiO_2	38.24	38.19	38.02	37.87	37.61	38.61	38.23	38.63	38.26	37.51
TiO_2	0.02	0.02	/	0.04	0.25	0.04	0.14	/	0.40	0.13
Cr_2O_3	0.10	0.32	0.12	0.03	/	0.50	0.20	0.13	/	/
Al_2O_3	20.38	20.52	20.03	20.72	20.47	21.18	21.10	21.38	20.43	20.56
Fe_2O_3	1.95	1.75	2.04	1.92	2.22	0.26	0.21	0.37	1.44	2.32
FeO	24.86	23.65	23.59	23.46	23.12	23.04	23.65	23.27	24.45	23.87
MnO	5.19	5.11	4.90	4.70	5.06	4.71	4.99	4.71	5.44	5.10
MgO	4.68	5.31	4.60	5.72	5.54	5.99	5.39	5.60	4.63	5.74
CaO	5.72	5.93	6.50	5.74	5.86	5.56	5.22	5.88	5.77	4.96
Σ	101.15	100.79	99.80	100.20	100.12	99.90	99.13	99.97	100.82	100.19
Number of ions on the basis of 24(O) – Број јона на бази 24(O)										
Si	2.995	2.985	3.012	2.968	2.957	3.018	3.023	3.020	3.004	2.949
Ti	.0012	.0012	.0000	.0024	.0148	.0024	.0083	.0000	.0236	.0077
Cr	.0062	.0198	.0075	.0019	.0000	.0309	.0125	.0080	.0000	.0000
Al	1.881	1.890	1.870	1.914	1.896	1.951	1.966	1.970	1.891	1.905
Fe^{3+}	.1151	.1027	.1219	.1135	.1311	.0155	.0124	.0215	.0854	.1374
Fe^{2+}	1.629	1.546	1.563	1.537	1.520	1.506	1.564	1.521	1.605	1.569
Mn	.3444	.3384	.3289	.3120	.3370	.3119	.3343	.3120	.3619	.3397
Mg	.5465	.6188	.5433	.6682	.6493	.6979	.6354	.6527	.5420	.6727
Ca	.4801	.4967	.5518	.4820	.4937	.4657	.4423	.4926	.4855	.4179
Gros.	9.90	10.40	12.00	10.20	9.20	13.20	13.20	15.00	10.80	6.70
Alm.	54.30	51.50	52.30	51.30	50.70	50.50	52.60	51.10	53.60	52.30
Pyr.	18.20	20.60	18.20	22.30	21.60	23.40	21.30	21.90	18.10	22.40
Spes.	11.50	11.30	11.00	10.40	11.20	10.50	11.20	10.50	12.10	11.30
Andr.	5.80	5.10	6.10	5.70	6.60	0.80	0.60	1.10	4.30	6.90
Uvar.	0.30	1.00	0.40	0.10	0.00	1.60	0.60	0.40	0.00	0.00
Ti/Al	0.10	0.10	0.00	0.10	0.70	0.10	0.40	0.00	1.20	0.40

o – rim of grain (центар зрна); • – core of grain (ободни део зрна).

Epidote and prehnite are of secondary origin, formed after plagioclases. The chemistry of epidote is presented in the Table 5.

Table 5. Microprobe analyses of epidote.
Табела 5. Хемијски састав епидота.

%	1	2
SiO_2	39.52	39.00
TiO_2	0.08	0.52
Al_2O_3	25.16	22.93
FeO	9.30	12.01
MnO	0.56	0.09
MgO	/	/
CaO	22.72	23.44
Na_2O	/	/
Σ	97.34	98.00
Number of ions on the basis of 12.5(O) – Број јона на бази 12,5(O)		
Si	2.936	3.055
Ti	0.005	0.031
Al	2.422	2.115
Fe^{3+}	0.635	0.786
Fe^{2+}	0.000	0.000
Mn	0.039	0.006
Mg	0.000	0.000
Ca	1.990	1.967
Na	0.000	0.000
^{IV}Al	0.064	0.000
^{VI}Al	2.358	2.115
Ps	0.2	0.3

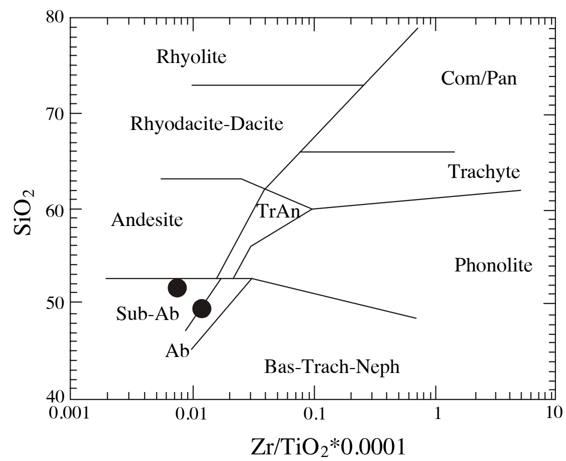

Fig. 3. Position of amphibolites from the village of Tejići on SiO_2 – $Zr/TiO_2 \times 0.0001$ diagram (Winchester & Floyd, 1977).

Сл. 3. Положај амфиболита Тејића на SiO_2 – $Zr/TiO_2 \times 0,0001$ дијаграму (Winchester & Floyd, 1977; Rhyolite = риолит, Rhyodacit–Dacite = Риодацит–дацит, Andesite = андезит, Sub–Ab = субалкални базалти, Ab = алкални базалти, TrAn = трахиандезит, Com/Pan = комендит/панталерит, Trachyte = трахит, Phonolite = фонолит, Bas–Trach–Neph = базанит–трахит–нефелинит).

GEOCHEMISTRY

Chemical composition of an amphibolite with garnet, and of an amphibolite without garnet, as well as their CIPW–norm composition is given in the Table 6. Garnet amphibolite has been analysed, as it has been noted, as the rock of highest metamorphic grade, while the other one (without garnet), has been chosen only for comparation. Their trace elements content, as well as REE concentration is presented on Table 7. Comparation of their chemical composition with chemistry of mafic volcanic rocks, in attempt to identify a possible protolith, indicates that both of amphibolites correspond to subalkaline basalts (Fig. 3).

Table 6. Major oxides (wt%) and CIPW–norm values in amphibolites.
Табела 6. Садржај главних оксида и вредности CIPW–norm у амфиболитима.

%	1	2
SiO_2	49.34	51.55
TiO_2	1.22	1.48
Al_2O_3	18.08	14.70
Fe_2O_3	4.18	3.77
FeO	6.40	6.76
MnO	0.46	0.19
MgO	6.85	6.03
CaO	5.87	9.07
Na_2O	3.32	4.41
K_2O	2.58	0.93
P_2O_5	.25	0.11
LOI	2.35	1.19
Σ	100.46	100.42
CIPW–norm		
or	15.43	5.56
ab	27.69	37.57
an	27.06	17.72
ne	0.37	0.04
di	0.76	21.89
ol	23.89	8.62
mt	0.00	5.52
ap	0.55	0.24

1 – garnet amphibolite (амфиболит са гранатима);
2 – amphibolite without garnets (амфиболит без граната).

Table 7. Content of trace elements and REE in amphibolites.
Табела 7. Садржај микроелемената и елемената ретких земаља у амфиболитима Тејића.

Ppm	1	2
Sc	32	40
V	203	273
Cr	279	110
Co	46	40
Ni	206	64
Cu	76	37
Zn	107	146
Ga	21	19
Rb	87	16
Sr	93	142
Zr	153	112
Nb	17	7
Mo	3	/
Cs	9	6
Ba	267	121
W	35	10
Pb	17	8
Th	16	6
U	2	6
La	15.8	4.69
Ce	42.6	13.1
Nd	49.0	11.4
Sm	4.49	3.33
Eu	1.35	1.24
Gd	4.51	4.54
Dy	5.23	5.91
Ho	0.96	1.06
Er	3.03	3.76
Yb	3.04	3.67
Lu	0.43	0.52
Y	30.80	35.9

On E–MORB normalized diagram garnet–amphibolites display a nearly flat pattern and the absence of Eu anomaly indicating on their origin from ocean ridge basalts (Fig. 4).

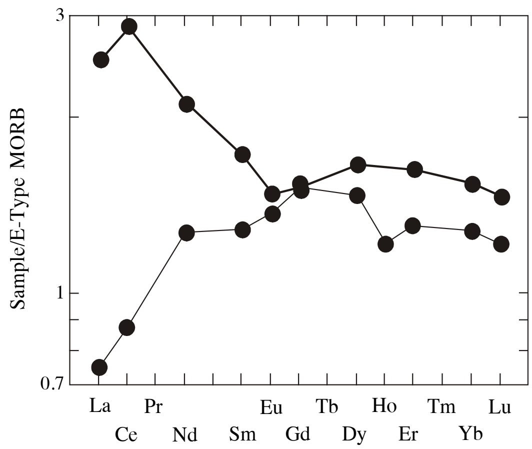

Fig. 4. E–MORB normalized REE patterns for amphibolites from the Tejići village (Sun & McDonough, 1989).
Сл. 4. Садржај елемената ретких земаља у амфиболитима Тејића у односу на E–MORB (Sun & McDonough, 1989; Sample/E–Type Morb = узорак/обогаћени базалт средњеокеанског гребена).

GEOHRONOLOGY

K/Ar age was determined by K. Balogh (Table 8) using hornblendas from three samples of amphibolites, including the garnet amphibolite.

Ages measured on hornblende concentrates from the garnet amphibolite (T–45) and from the amphibole schists (T–13b, T–24) agree within the limits of experimental errors and give the time when the rocks cooled below the closure temperature of hornblende. According to Harrison & McDougall (1980) the closure temperature of hornblende is 400–540°C, depending on the grain size and cooling rate. In our case a higher closure temperature of about 500°C is more acceptable becouse of high cooling rate.

Table 8. K/Ar ages on rocks from Tejići village (Analyzed by K. Balogh).
Табела 8. Резултати K/Ar анализа за амфиболите Тејића (Анал. K. Balogh).

Sample (узорак)	%K	Ar(rad)ccSTP/g	%Ar	age Ma +/–σ
T–45	0.78	5.073 × 10–6	69.9	160.0 +/– 6.2
T–13b	0.19	1.216 × 10–6	46.0	157.6 +/– 10.0
T–24	0.49	3.193 × 10–6	72.1	160.3 +/– 8.0

T–45 – garnet amphibolite / амфиболит са гранатима (Kosa);
T–13b – amphibolite schist / амфиболски шкриљац (Kosa);
T–24 – amphibolite schist / амфиболски шкриљац (Bela Stena).

Investigated rocks were metamorphosed on the contact with the ophiolite slab and the different degree of metamorphism is a result of different temperature, i.e. distance from the contact.

DEGREES OF METAMORPHISM

Those existing mineral assemblages were formed during the main stage of metamorphism in amphibolite facies conditions, on a temperature estimated about 620°C for supposed pressures from 4 to 7 kbar.

These results were obtained for a garnet–hornblende pair, as the best geothermometer:

Temperature interval according to:			Graham–Powell (1984):	629.27°–683.38°C;
-//-	-//-	-//-	Powell–Holland (1985):	604.79°–660.63°C;
-//-	-//-	-//-	Perchuk–Lavrenteva (1985):	625.86°–690.14°C.

CONCLUSION

Investigated amphibolites probably represent former basaltic rocks as members of the oceanic crust at the Mesozoic Vardar ocean. In the light of all mentioned data could be finally concluded that the ophiolite slab was hot during its emplacement and caused the metamorphism of rocks in its base in the amphibolite facies conditions. According to K/Ar analyses, that gave an age about 160 Ma, we can assume Upper Jurassic (Oxfordian) age as the age of this metamorphic event, as well as the time of beginning the ocean closure in this part of the Vardar Zone.

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РЕЗИМЕ

ПЕТРОЛОГИЈА ГРАНАТСКИХ АМФИБОЛИТА ТЕЈИЋА (ПОВЛЕН, ЗАПАДНА СРБИЈА)

Село Тејићи је смештено на југозападним падинама Повлена, у тзв. "Мезозојској зони" (Петковић, 1930–1931), која лежи између пространих области Дринско–ивањичког и Јадарског палеозоика. Геотектонски припада западној субзони Вардарске зоне (Karamata & Krstić; 1996, сл. 1), која је у овом делу навучена преко Дринско–ивањичког, односно Јадарског терана, па достиже ширину до 5 km.

Стене ове зоне сматране су (са изузетком крупних блокова) члановима "Дијабаз–рожначке формације" (Mojsilović et al., 1966, 1975) до 1974. године, кад су их Dimitrijević & Dimitrijević дефинисали као офиолитски меланж.

Околину Тејића изграђују чланови рашчлањеног офиолитског комплекса (ултрамафити, габрови, дијабази и према новим схватањима, метаморфити), тријаске, претежно карбонатне стене, лијаски и кредни кречњачки блокови, и подређено блокови пешчара у глиновито–алевритском матриксу. Офиолитске стене из подручја Тејића добиле су значај у геолошкој литератури због присуства метаморфних стена које су сматране најстаријим кристаластим стенама западне Србије (Mojsilović et al., loc. cit.).

"Метаморфити Тејића" се јављају на површини од само 2 km^2, а чине их амфиболити и други шкриљци, док су гнајсеви врло ретки. На ОГК 1:100.000, лист "Ваљево" су означени као $_1Pz^1$(?), али према новијим схватањима (Карамата и Миловановић, усмено саопштење) представљају делове офиолитског комплекса, односно метаморфну подлогу офиолита. Амфиболити са гранатима се јављају уз саме перидотите као изданци величине неколико метара и представљају стене највишег степена метаморфизма због чега су и најпогодније за одређивање P–T услова метаморфизма на контакту перидотита и околних стена. Амфиболити без граната (приказани у овом раду ради поређења) се јављају даље од контакта са ултрамафитима.

Амфиболити са гранатима су масивне, ретко тракасте стене, нематобластичне структуре. Изграђене су од амфибола (хорнбленде; табела 1; сл. 2), плагиокласа (примарног, трансформисаног у епидот–пренит и новообразованог, албита; табела 3) и граната (алмандина; табела 4). Секундарни су: хлорит (образован по амфиболским зрнима, по саставу корундофилит до рипидолит; табела 2), епидот и пре-

нит (настали на рачун плагиокласа; табела 5), а врло редак рутил је акцесорни минерал.

Поменута асоцијација минерала према предложеним геотермометрима различитих аутора настала је на температури од око 620°C и притисцима од 4–7 kbara што одговара амфиболитској фацији.

Хемијски састав амфиболита (табеле 6 и 7) указује да да су ове стене настале метаморфозом субалкалних базалта (сл. 3), који по саставу одговарају E–MORB–у (обогаћеном базалту средњеокеанских гребена; сл. 4).

Одређена изотопска старост амфиболита, K/Ar методом, на три узорка, дала је време од 160 милиона година (табела 8), што одговара горњој јури (оксфорд).

Добијени резултати указују да су амфиболити Тејића највероватније базалти океанске коре мезозојског Вардарског океана, метаморфисани приликом затварања океана, које је започело почетком горње јуре. Метаморфизам је изазвао још увек загрејан офиолитски блок (на изнад 620°C).